BME/MSE 410 Design and Applications of Biomaterials

**Semester:** Fall, 2015  
**Days/Times:** Monday/Wednesday 10.00-11:30 AM  
**Classroom:** 133 Chrysler

**Professor:** Geeta Mehta, Ph.D.  
Dept. of Materials Science and Engineering, Biomedical Engineering, and Macromolecular Science and Engineering

**Office:** 2102 H. H. Dow  
**Office Hours:** Immediately after class or via Email  
**E-mail:** mehtagee@umich.edu

**GSI:** Hong Zhou (hongzhou@umich.edu)  
**Office Hours:** Mondays and Fridays 4-5 pm  
2185 LBME Building

**Prerequisites:** One year of general biology or biochemistry and MSE 220 or 250.

(Book is available online via UMich Library:  
http://mirlyn.lib.umich.edu/Record/012216410  
Pertinent Chapters from Ratner are posted on CTools)

**Course website:** https://ctool.umich.edu/

**Useful Websites:**  
• The Web of Science Citation Index:  
http://isi10.newisiknowledge.com/portal.cgi  
 (need to use from on campus or with your umich uniquename and password)

**Accommodations for Students with Disabilities:**  
If you think you need an accommodation for a disability, please let me know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way we teach may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, we can work with the Office of Services for Students with Disabilities (SSD) to help us determine appropriate accommodations. SSD (734-763-3000 or ssd.umich.edu) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. I will treat any information you provide as private and confidential.
I. Course Goals
1) Development of global perspective of interdisciplinary issues (biology, materials science, chemistry, and engineering) involved in biomaterials.
2) Learn how to design, synthesize, evaluate, and analyze biomaterials.
3) Critical thinking and analysis.
4) Communication of ideas; communication to coordinate work
5) Familiarization with biomaterials literature.

Structure of Lectures
1. Materials (Lectures 1-2)
   Bulk properties and surface properties
2. Class of materials used in biomedical applications (Lectures 3 - 12)
3. Biological interactions with materials (Lectures 13 - 22)
   Proteins, cells, and tissues
   Host reactions: Inflammation, immunology, toxicity, coagulation, and tumorigenesis.
4. Applications of biomaterials (All throughout the course, and Lectures 23 – 26): cardiovascular, orthopedic, dental, skin, functional tissues, etc.)

II. Grading
(a) 2 midterm exams (200 pt.; 100 + 100): 20% of grade each
(b) Homeworks: 15% of grade
(c) Class Participation: 10% of grade
(d) Final Exam (100 pt.): 35% of grade

III Exams: Exams will be split between short-answer type questions and quantitative problems with opportunities for partial credit. Important concepts that might appear on exams will be highlighted in each lecture.

For the midterm exams, I will allow 1 side of 1 equation sheet (8.5x11 inch) (include name neatly) turned in with your exam. This will be returned along with your graded exam.

Final Exam prep: There will be an overall review sessions before the final exam. For the final exam, 2 pages of equation sheets are allowed, and must be turned in with your exam.

Final exam will be cumulative. There will be questions from the guest lecture on the final exam.

IV Homework

HWs discussion with other students in the class: You may discuss HWs with your classmates (it is expected), and work towards solutions together. You must submit individual work that is not a verbatim copy of any other student's work. Do not forget that even when working in groups, you are individually responsible for your learning.

HWs will be collected by the GSI each time they are due, at the beginning of the class.
Late HW Policy:
Same day late HW: 15% deduction
Next day late HW: 50% deduction
Third day late HW: 100% deduction

Class participation: To ensure active learning and engagement in class, we will be using the iClicker system in lectures. Your personal iClicker must be registered under your uniqname and UMID. Your responses to in-class questions will be recorded via iClicker, and these will go towards your participation points.

We will also conduct active learning exercises during each class. Your participation is essential for these activities, and will count towards your participation points.

Course Evaluation: Your feedback is extremely important to make this course better and to improve your learning experience. To encourage course evaluation, I will be awarding extra points:
- If more than 90% of the class completes the final class evaluations, 5 points (from the class participation points) will be awarded to all students.
- With your last homework assignment, staple a receipt of your course evaluation, and you will be awarded an extra 2 points towards your homework points.

Please note that the course evaluations are anonymous and the final evaluations aren’t available to me until after your final course grades have been submitted.

Journals relevant to Biomaterials
- Minimum you should browse through
  Nature
  Science
  Nature Biotech
  Nature Materials
  Nature Communications
  Proceedings of the National Academy of Science USA (PNAS)
  Biomaterials
  Journal of the American Chemical Society (JACS)
  European Cells & Materials (eCM)
  Lab on a Chip
  Nanomedicine
  Soft Matter
  Journal of Biomedical Materials Research Part A

- Others (just some examples, there are more, See Appendix D in Textbook)
VIII Other Textbooks and References (Also see Appendix D in Textbook)

Atala, A; Mooney, D. J. Eds Synthetic Biodegradable Polymer Scaffolds, Springer Verlag, New York, 1997

IX Honor Code Statement: All students in the BME/MSE/Macro 410 are presumed to be decent and honorable, and as such, are bound by the College of Engineering Honor Code. You may not seek to gain an unfair advantage over your fellow students; you may not consult, look at, or possess the unpublished work of another without their permission; and you must appropriately acknowledge your use of another's work. Any violation of the honor policies appropriate to each piece of course work will be reported to the Honor Council, and if guilt is established penalties may be imposed by the Honor Council and Faculty Committee on Discipline.
## X. Course Outline

<table>
<thead>
<tr>
<th>#</th>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
<th>Homework</th>
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<tbody>
<tr>
<td>1</td>
<td>September 9 (Wed)</td>
<td>Orientation and Introduction to Biomaterials</td>
<td>Ratner: pp xxv to xxxvii, xli-lii</td>
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<td>2</td>
<td>September 14 (Mon)</td>
<td>Material Properties, Surface Characterization</td>
<td>Ratner: pp 5-21, 34-59</td>
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<td>3</td>
<td>September 16 (Wed)</td>
<td>Surface Characterization and Polymers</td>
<td>Ratner: pp 34-59, 63-109</td>
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<td>4</td>
<td>September 21 (Mon)</td>
<td>Polymers and Hydrogels</td>
<td>Ratner: pp 63-109, 166-176</td>
<td>HW#1 Due</td>
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<td>5</td>
<td>September 23 (Wed)</td>
<td>Hydrogels, Smart Polymers</td>
<td>Ratner: pp 166-176, 247-255</td>
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<td>6</td>
<td>September 28 (Mon)</td>
<td>Medical Fibers and Biotextiles, Biodegradable materials</td>
<td>Ratner: pp 301-319, 179-193</td>
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<td>7</td>
<td>September 30 (Wed)</td>
<td>Biodegradable materials, Natural materials</td>
<td>Ratner: pp 179-193, 195-206</td>
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<td>8</td>
<td>October 2 (Mon)</td>
<td>Natural materials, Surface Modification, REVIEW</td>
<td>Ratner: pp 259-273</td>
<td>HW#2 Due</td>
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<td>9</td>
<td>October 7 (Wed)</td>
<td>MIDTERM EXAM</td>
<td>Lectures 1-8</td>
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<td>During class hours</td>
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<td>10</td>
<td>October 12 (Mon)</td>
<td>Surface Patterning, Metals</td>
<td>Ratner: pp 276-296, 111-159</td>
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<td>11</td>
<td>October 14 (Wed)</td>
<td>Metals, Ceramics and Glasses</td>
<td>Ratner: pp 111-159</td>
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<td>October 19 (Mon)</td>
<td>STUDY BREAK</td>
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<td>14</td>
<td>October 28 (Wed)</td>
<td>Proteins on biomaterials</td>
<td>Ratner: pp 394-408</td>
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<td>15</td>
<td>November 2 (Mon)</td>
<td>Proteins on biomaterials, Non fouling surfaces</td>
<td>Ratner: pp 394-408, 241-247</td>
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<td>16</td>
<td>November 4 (Wed)</td>
<td>Cell/tissue biomaterial interactions, Cells and surfaces, Biological response to biomaterials</td>
<td>Ratner: pp 408-422, 452-473, 499-503</td>
<td>HW#4 Due</td>
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<tr>
<td>17</td>
<td>November 9 (Mon)</td>
<td>Biological response to biomaterials, Inflammation and immunity, REVIEW</td>
<td>Ratner: pp 499-503, 503-532</td>
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<td>18</td>
<td>November 11 (Wed)</td>
<td>MIDTERM EXAM</td>
<td>Lectures 10-17</td>
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<td>During class hours</td>
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<td>19</td>
<td>November 16 (Mon)</td>
<td>Adaptive Immunity, Toxicity, Hypersensitivity, Tumorigenesis</td>
<td>Ratner: pp 545-565</td>
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<td>20</td>
<td>November 18 (Wed)</td>
<td>Clotting and Unclotting, Blood-Material interactions, Biofilms</td>
<td>Ratner: pp 551-558, 565-576,</td>
<td>HW#5 Due</td>
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<td>21</td>
<td>November 23 (Mon)</td>
<td>Biological testing of biomaterials</td>
<td>Ratner: pp 587-633</td>
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<td>22</td>
<td>November 25 (Wed)</td>
<td>Degradation of materials in the biological environment, Pathological Calcification</td>
<td>Ratner: pp 695-750, 739-754</td>
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<td>23</td>
<td>November 30 (Mon)</td>
<td>Cardiovascular Applications</td>
<td>Ratner: pp 760-809</td>
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<td>24</td>
<td>December 2 (Wed)</td>
<td>Cardiovascular Applications, Orthopedic Applications</td>
<td>Ratner: pp 760-809, 841-878</td>
<td>HW#6 Due</td>
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<td>25</td>
<td>December 7 (Mon)</td>
<td>Orthopedic and Dental Applications</td>
<td>Ratner: pp 841-878, 882-888</td>
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<td>26</td>
<td>December 9 (Wed)</td>
<td>Adhesives, Sealants, Sutures, Skin Substitutes</td>
<td>Ratner: pp 889-905, 1006-1023</td>
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<td>27</td>
<td>December 14 (Mon)</td>
<td>Overall Course Review</td>
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